BULLETIN

OF THE INSTITUTE OF METALS

VOLUME 1 MAY 1953 PART 21

INSTITUTE NEWS

Autumn Meeting, Southport, Monday to Friday, 21 to 25 September

As previously announced, the 1953 Autumn Meeting will be held in South Lancashire, by invitation of the Councils of the Manchester Metallurgical Society and the Liverpool Metallurgical Society. Because of hotel accommodation problems in Chester, Liverpool, and Manchester, the meeting will be held at Southport, where the accommodation for such conferences is adequate and from which a wide range of visits is possible.

Reception Committee

The following have agreed to serve on the Reception Committee:

Lieut.-Commander G. K. RYLANDS, *Chairman* (Rylands Brothers, Ltd., Warrington).
Dr. W. E. ALKINS (Thomas Bolton and Sons, Ltd., Stoke-on-Trent).
Mr. H. ALLISON (Metropolitan-Vickers Electrical Co., Ltd., Manchester).
Dr. S. F. BARCLAY (Mather and Platt, Ltd., Manchester).
Mr. Eric BOWYER (British Insulated Callender's Cables, Ltd., Prescot).
Mr. C. F. BRERETON (Richard Johnson and Nephew, Ltd., Manchester).
Mr. R. S. BROWN (Rylands Brothers, Ltd., Warrington).
Mr. G. T. CALLIS (Manganese Bronze and Brass Co., Ltd., Birkenhead).
Mr. B. G. CHURCHER (Metropolitan-Vickers Electrical Co., Ltd., Manchester).
Mr. C. T. DAVEY (Thomas Bolton and Sons, Ltd., Widnes).
Sir ROY H. DOBSON (A. V. Roe and Co., Ltd., Middleton).
Mr. I. W. F. FAIRHOLME (Richard Johnson and Nephew, Ltd., Manchester).
Mr. W. L. GOVIER (Imperial Chemical Industries, Ltd., Metals Division, Kirby).
Capt. A. C. JESSUP (Magnesium Elektron, Ltd., Clifton Junction).
Dr. W. L. KENT (The British Aluminium Co., Ltd., Warrington).
Mr. I. S. KERR (The Lancashire Steel Corporation, Ltd., Irlam).
Mr. L. ROTHERHAM (Ministry of Supply, Risley).
Mr. F. R. SMITH (The English Electric Co., Ltd., Stafford).
Professor F. C. THOMPSON (University of Manchester).
Mr. W. T. T. WILCOX (Shell Refining and Marketing Co., Ltd.).

Mr. S. V. RADCLIFFE (Rylands Brothers, Ltd.) has agreed to act as Honorary Secretary to the Reception Committee.

Provisional Programme

The following provisional programme has been approved:

Mon., 21 *Sept.*
Aft. Members and guests register.
Evg. Autumn Lecture, by Dr. MAURICE COOK, in the Town Hall.

Tues., 22 *Sept.*
Morn. Official Welcome to Members by the Mayor of Southport.
Scientific Session "A" (papers on subjects relating to industrial metallurgy), side by side with
Scientific Session "B" (physical metallurgy).
Aft. Visits to works and laboratories and Ladies' visits.
Evg. Civic Reception, with dancing, at the Town Hall, by invitation of the Mayor of Southport.

Wed., 23 *Sept.*
All-day. Visits to works and laboratories located at a considerable distance from Southport (e.g. in the Manchester area) and Ladies' visit to Chester.
Evg. Banquet at the Prince of Wales Hotel.

Thurs., 24 *Sept.*
Morn. Scientific Session "A" (papers of general interest), side by side with
Scientific Session "B"—Informal Discussion on "Damping Capacity", to be arranged by the Metal Physics Committee.
Aft. Visits to works and laboratories and Ladies' visits.
Evg. Free.

Fri., 25 *Sept.*
All-day. Tour to the Lake District.

Accommodation

Accommodation for members and their guests has already been reserved at the Prince of Wales Hotel and the Brunswick Hotel, at Southport, particulars of which are given below. It has not been found possible to book inexpensive accommodation in Southport for students, but arrangements have been made by which students and other members may stay at Derby Hall (a University hostel) at Liverpool, travelling to Southport by train (20 minutes) daily. The station at Southport is close to the place of meeting and the centre of the town. Particulars are given below. The hotel marking is the Automobile Association grading.

****** Prince of Wales Hotel**, Lord Street, Southport. Inclusive daily terms: 39*s.* 6*d.* or 42*s.* per person, according to position of room. Private bathroom, 7*s.* 6*d.* extra. Some private suites are available. Bed and breakfast terms, daily:

30*s.* per person. An allowance of 5*s.* will be made to members attending the Banquet. The hotel is in first-class order and can be confidently recommended.

Brunswick Hotel, Lord Street, Southport (A.A. approved). Rooms have been reserved in the hotel, with additional rooms at nearby houses, with the amenities and all meals in the hotel. Inclusive daily terms: 28*s.* 6*d.* per person sleeping in the hotel; 26*s.* 6*d.* for those sleeping out of the hotel.

Derby Hall, North Mossley Hill Road, Liverpool. Daily charges for bed and breakfast: Bona fide students, 10*s.* per day; senior members, 14*s.* per day. Dinner (if ordered), 3*s.* 6*d.*

Bookings of hotel accommodation can now be requested and, in the case of the reserved accommodation mentioned above, *must be made with the Institute and not with the hotel or hostel.* The Institute must pay a deposit on rooms booked at Derby Hall. Accommodation at Derby Hall is also being made available to other conferences, and members wishing to stay there should, therefore, book at the earliest possible opportunity, so that rooms may be reserved for them.

In an Annexe to Derby Hall, 12 double rooms are available. Members requiring them should apply with the least possible delay.

General Information

Particulars of the programmes of papers to be discussed and works and laboratories to be visited will be published as early as possible. It is expected that a full programme, with Reply Forms, will be posted in July to members resident in Europe. Members resident outside Europe who hope to attend the meeting should apply to the Secretary to receive a copy of the full programme (which will also be published in the *Bulletin*) and the Reply Form.

Election of Members

The following 27 Ordinary Members, 1 Junior Member, and 11 Student Members were elected on 23 March 1953:

As Ordinary Members

Boys, Sydney Joseph Henry, L.I.M., Chief Metallurgist, Thompson Brothers (Bilston), Ltd., Bilston, Staffs.

Braithwaite, Wilfrid Rolf, B.Met., Metallurgist, Magnesium Elektron, Ltd., Clifton Junction, near Manchester.

Bruce, Fraser W., Managing Director, Northern Aluminium Co., Ltd., Bush House, London, W.C.2.

Bull, Harry, Assoc.Met., F.I.M., Managing Director, Brown Bayley Steels, Ltd., Leeds Road, Sheffield 9.

Bull, James Reginald Ashworth, Managing Director, Sanderson Brothers and Newbould, Ltd., Attercliff Works, Newhall Road, Sheffield.

Cousins, (Miss) Kathleen Marjorie, A.I.M., Metallurgist, Rubery, Owen and Co., Ltd., Darlaston, Staffs.

Dalton, Charles Arthur, B.Sc., A.I.M., Chief Metallurgist, Armstrong Siddeley Motors, Ltd., Parkside, Coventry.

Desoer, Adrien, Ing. Civil des Mines, Directeur Général Adjoint, Société Anonyme d'Ougrée-Marihaye, Ougrée (Liège), Belgium.

Dürrwächter, Eugen, Dr.Ing., Direktor, Platinschmelze Dr. E. Dürrwächter, Postfach 118, Pforzheim, Germany.

Gore, James, Technical Superintendent, British Insulated Callender's Cables, Ltd., Prescot, Lancs.

Haselgrove, J., Chief Metallurgist and Assistant Works Manager, United Wire Works (Birmingham), Ltd., Adderley Street, Birmingham.

Hawkins, Charles Cecil, Director, Mark Perks, Ltd., 43 Vyse Street, Birmingham 18.

Henshaw, George Stanley, A.C.T., Development Engineer, T. I. Aluminium, Ltd., Birmingham 11.

Hodierne, Francis Arthur, B.Sc., A.I.M., Research Metallurgist, Department of Development and Research, T.I. (Group Services), Ltd., Plume Street, Birmingham 6.

Keil, Albert, Dr.phil.nat., Leiter des Forschungs-Laboratoriums, Platinschmelze Dr. E. Dürrwächter, Postfach 118, Pforzheim, Germany.

Lueling, Henry, Dipl. Ing., Research and Development Engineer, George Fischer, Ltd., Schaffhausen, Switzerland.

Mullins, James Edgar, B.Eng., Graduate Apprentice Metallurgist, D. Napier and Son, Ltd., East Lancashire Road, Liverpool.

Orlando, Attilio, Dott. Ing., In charge of Rolling Department, Società Metallurgica Italiana, Fornaci di Barga (Lucca), Italy.

Page, Frederick Vernon, Technical Representative, London Electric Wire Company and Smiths, Ltd., 31 Spenser Street, London, S.W.1.

Silman, Harold, B.Sc., F.R.I.C., A.M.I.Chem.E., F.I.M., Research Manager, Ford Motor Co., Ltd., Research Department, Lodge Road, Birmingham 18.

Soliman, Sanaa Mohammed, B.Sc., Works Manager, Mechanical Transport, Cairo, Egypt.

Smith, Edward William, Manager, Mark Tyzack and Sons, Ltd., Carver Street, Sheffield 1.

Tallis, Charles Edward, Group Development Engineer, Denbro, Ltd., 222 Soho Hill, Birmingham 19.

Tracey, Lewis Johnson, Managing Director, Stock Sons and Taylors, Ltd., 19 Gas Street, Birmingham 1.

Wheaton, George William, B.Sc., Assistant Wire-Drawing-Mill Superintendent, British Insulated Callender's Cables, Ltd., Prescot, Lancs.

Widdowson, James George, Managing Director, Jonas and Colver, Ltd., Novo Steel Works, Sheffield 9.

Youngkrantz, Howard R., B.S., Chief Engineer, Apex Smelting Company, 2537 West Taylor Street, Chicago 12, Ill., U.S.A.

As Junior Member

Knowles, Allan John, Senior Analyst, Elkington and Co., Ltd., Goscote Works, Goscote, near Walsall, Staffs.

As Student Members

Booth, Frederick Fenwick, Student of Metallurgy, Battersea College of Technology, London, S.W.11.

Davies, Raymond Oswald, Department of Metallurgy, University College of Swansea.

Elliott, Bryan J., B.Sc., Research Student, Department of Metallurgy, University of Manchester.

Fletcher, Harry Olwyn, Metallurgical Student, Stewarts and Lloyds, Ltd., Bilston, Staffs.

Gupta, B. K., M.Sc., Trainee, Enfield Rolling Mills, Ltd., Enfield, Middx.

Jeffreys, John Thomas Llewelyn, Student of Metallurgy, University College of Swansea.

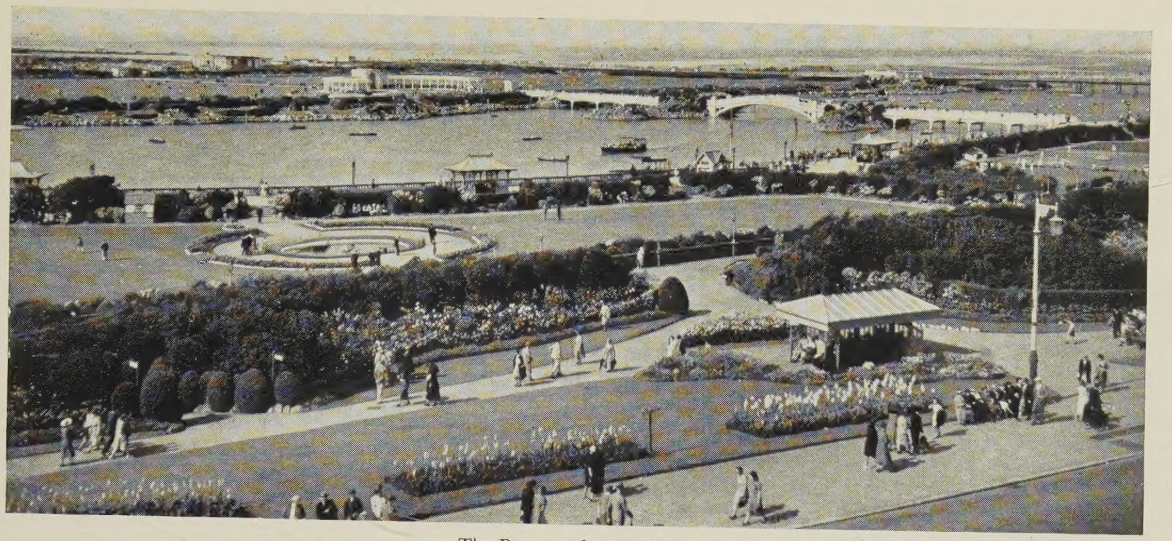
Piercy, George Robert, M.A.Sc., Research Student, Department of Metallurgy, University of Birmingham.

Stokes, Robert James, B.Sc., Department of Metallurgy, University of Birmingham.

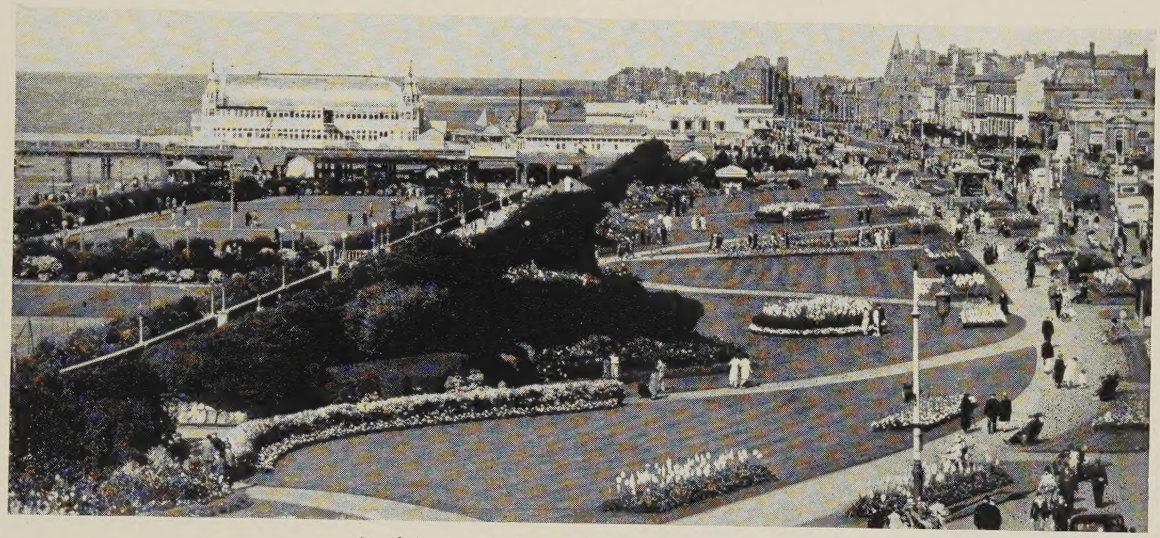
Williams, Alan James, M.Sc., Research Student, Department of Metallurgy, University of Birmingham.

Williams, (Miss) Joan, B.Sc., Chemist, Richard Thomas and Baldwins, Ltd., Wern Aluminium Works, Briton Ferry, Neath, Glam.

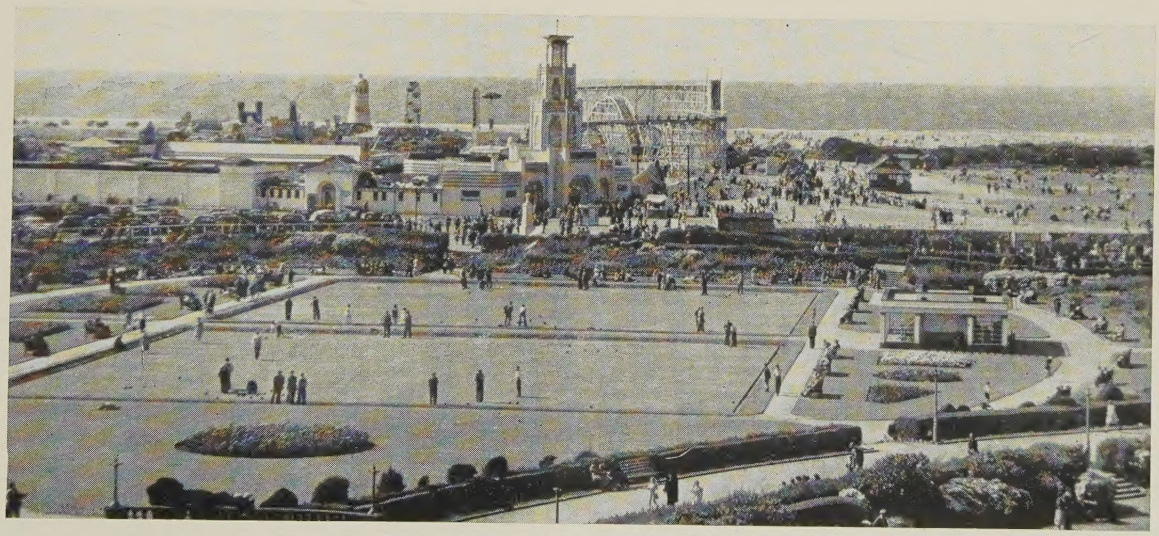
Williams, Keith Juxon, Student of Metallurgy, University of Manchester.



The Promenade, Southport.



South Marine Park and King's Gardens, Southport.



Bowling Greens and Pleasureland, Southport.

Photos : Valentine, Dundee.

COUNCIL 1953–54

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Thompson, Professor F. C., D.Met., M.Sc., F.I.M.; Professor of Metallurgy, University of Manchester.

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Bond-Williams, N. I., B.Sc., A.I.M.; Chairman and Managing Director, The Aston Chain and Hook Co., Ltd., Birmingham.

Clarke, K. W., F.I.M.; Chief Metallurgist, The de Havilland Aircraft Co., Ltd., Central Laboratories, Edgware.

Colquhoun, J. C., M.B.E.; Chairman and Managing Director, The Manganese Bronze and Brass Co., Ltd., Ipswich and Birkenhead; Chairman, Lightalloys Ltd., London.

Gadd, E. R., F.I.M.; Chief Metallurgist, The Bristol Aeroplane Co., Ltd., Engine Division, Filton, Bristol.

Grimston, The Hon. John, M.P.; Director and General Manager, Enfield Rolling Mills, Ltd., Brimsdown, Enfield; Director, Enfield Copper Refining Co., Ltd.; Director, Enfield Rolling Mills (Aluminium), Ltd.; Director, Enfield Zinc Products, Ltd.

Inglis, N. P., Ph.D., M.Eng., M.I.Mech.E., F.I.M.; Research Director, Imperial Chemical Industries, Ltd., Metals Division, Birmingham.

Jenkins, Ivor, D.Sc., F.I.M.; Chief Metallurgist, Research Laboratories of The General Electric Co., Ltd., Wembley, Middlesex.

Pfeil, L. B., O.B.E., D.Sc., A.R.S.M., F.R.S., F.I.M.; Director, The Mond Nickel Co., Ltd.; Director, Henry Wiggin and Co., Ltd.

Ramsay, A. G., Ph.D., B.Sc., A.R.I.C.; Director, The Mond Nickel Co., Ltd., Swansea.

Smith, Christopher, F.I.M.; Works Superintendent, James Booth and Co., Ltd., Birmingham.

Sutton, H., C.B.E., D.Sc., F.R.Ae.S., F.I.M.; Director, Materials Research and Development (Air), Ministry of Supply.

Teed, Major P. Litherland, A.R.S.M., F.R.Ae.S., F.I.M., M.I.M.M.; Assistant Chief of Aeronautical Research and Development, Vickers-Armstrongs, Ltd. (Aircraft Section), Weybridge, Surrey.

Thomas, W. J., M.I.Mech.E., M.I.E.E.; Assistant Managing Director, The British Aluminium Co., Ltd.; Director, North British Aluminium Co., Ltd.; Director, Lochaber Power Co.; Director, Imperial Magnesium Corporation, Ltd.; Director, William Mills, Ltd.; Director, Alumina Co., Ltd.; Director, Gold Coast Bauxite Co., Ltd.; Director, Aluminium Corporation, Ltd.; Director, British and Colonial Bauxite Co., Ltd.; Director, Alliance Aluminium Holdings, Ltd.; Director, Aluminium Wire and Cable Co., Ltd.

Ex-officio : Chairmen of Local Sections

Birmingham

Symonds, H. H., F.I.M., Foundry Manager, H. B. Barnard and Sons, Ltd., Dudley Port, Staffs.

London

Ransley, C. E., Ph.D., M.Sc., F.I.M., Metallurgist, The British Aluminium Co., Ltd., Gerrards Cross, Bucks.

Oxford

Parker, R. T., Ph.D., B.Sc., A.R.S.M., Director of Research, Aluminium Laboratories, Ltd., Banbury, Oxon.

Scottish

Fowler, E. A., B.Sc., A.R.T.C., Chief Metallurgist and Chemist, Scotts' Shipbuilding and Engineering Co., Ltd., Greenock.

Sheffield

Hallett, M. M., M.Sc., F.I.M., Research and Development Manager, Sheepbridge Engineering, Ltd., Chesterfield.

South Wales

Spring, K. M., A.I.M., Assistant Technical Officer, Imperial Chemical Industries, Ltd., Metals Division, Landore, Swansea.

Representatives of Other Bodies :

The following, in accordance with Article 32, represent Government departments and allied societies at Council meetings, for purposes of liaison :

The Admiralty

Grylls, Captain (E.) H. J. B., R.N.

The War Office

Joslin, Major-General S. W., C.B.E., M.A., M.I.Mech.E.

The Institution of Metallurgists

Cook, Maurice, D.Sc., Ph.D., F.I.M.
West, E. G., Ph.D., B.Sc., F.I.M.

The Iron and Steel Institute

Mitchell, James, C.B.E.

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Belgium : H. P. A. Féron.
Canada : Professor B. Chalmers, Ph.D., D.Sc., and Professor G. Letendre, B.A., Ph.D.
France : Professor P. A. J. Chevenard and J. Matter.
India : N. P. Gandhi, M.A., B.Sc., A.R.S.M., D.I.C.
Italy : Leno Matteoli, Dott.Chim.
Netherlands : M. Hamburger.
South Africa : G. H. Stanley, D.Sc., A.R.S.M., and Professor L. Taverner, A.R.S.M., D.I.C.
Spain : Professor J. Orland, M.Sc., M.A., Ph.D., D.D.
Sweden : Professor Carl A. F. Benedicks, Fil.Dr., Dr.Ing.e.h., Dr.Techn.h.c., and Professor Axel Hultgren.
Switzerland : Professor A. von Zeerleder, Dr.-Ing.
United States of America : Professor R. F. Mehl, Ph.D., Hon.Eng.D., Hon.Sc.D., Professor C. S. Smith, Sc.D., and Dr. R. A. Wilkins.

PERSONAL NOTES

Professor P. G. Bastien, has been appointed Director of Scientific Research at the Ecole Centrale des Arts et Manufactures, Paris, in succession to Professor A. Portevin.

Mr. G. W. Booth has been elected President of the British Bronze and Brass Ingot Manufacturers' Association for the third year in succession.

Mr. L. M. Clarebrough has returned to the Division of Tribophysics, Commonwealth Scientific and Industrial Research Organization, University of Melbourne, after spending 15 months in England.

Dr. E. C. Ellwood, until recently Senior Lecturer in Metallurgy at King's College, Newcastle-upon-Tyne, has joined the Tin Research Institute, Greenford, Middlesex, as Chief Metallurgist.

Mr. P. Flatley has left Associated Lead Manufacturers, Ltd., Chester, and taken up a post as Assistant Smelting Manager with McKechnie Brothers, Ltd., Widnes.

Mr. R. S. Jackson has left David Brown Foundries Co., Penistone, and has joined the staff of the British Non-Ferrous Metals Research Association as an Investigator in the Castings Section.

Mr. J. E. Jenkins has resigned his post with Enna, Ltd., Perivale, in order to take up an appointment as metallurgist with Magnesium Elektron, Ltd., Clifton Junction.

Dr. O. T. Marzke, Superintendent of the Metallurgy Division at the U.S. Naval Research Laboratory, Washington, D.C., has been appointed Consultant to the Director of Research at N.R.L. in the fields of chemistry, electricity, mechanics, and metallurgy.

Dr. A. J. W. Moore has left the Research Laboratory on the Physics and Chemistry of Surfaces at Cambridge and has returned to Australia, where he will rejoin the Division of Tribophysics of the Commonwealth Scientific and Industrial Research Organization at Melbourne University.

Dr. F. R. N. Nabarro, Lecturer in Metallurgy at Birmingham University, has been appointed to the Chair of Physics at Witwatersrand University, Johannesburg.

Professor Hugh O'Neill, President of the Institution of Metallurgists, has been admitted as a permanent member of the General Committee of the British Association for the Advancement of Science.

Mr. A. R. Powell, Research Manager of Johnson, Matthey and Co., Ltd., has been elected a Fellow of the Royal Society.

Mr. S. T. Quaass has left the National Gas Turbine Establishment and returned to the Aeronautical Research Laboratories, Melbourne.

Mr. W. Rachinger has recently been awarded the Ph.D. degree of Melbourne University.

Mr. W. J. Roberts has joined Arrow Press, Ltd., Watford, as Editor of *Industrial Finishing*.

Sir Arthur Smout retired from the Board of Imperial Chemical Industries, Ltd., on 28 February. He was appointed to the Board in 1944 and in the same year became Metals Group Director. In July 1951 he also took over responsibility for the Nobel Division. Sir Arthur served for 48 years with the Company and its predecessors, having joined Elliotts Metal Co., Ltd., in 1905. From 1934 until 1942 he was Chairman of the Delegate Board of I.C.I. (Metals), Ltd. From 1942 to 1945 he was Director-General of Ammunition Production at the Ministry of Supply, being knighted for his services in 1946. He was President of the Institute from 1948 to 1950.

Dr. P. Vajragupta has been transferred from the Government Department of Mines to the Department of Metallurgical Works, Ministry of Industry, Bangkok.

Mr. H. L. Wain has been awarded the Ph.D. degree of Birmingham University.

Deaths

The Editor regrets to announce the deaths of :

Mr. Kenneth Joseph Forrest, Technical Officer, Imperial Chemical Industries, Ltd., Metals Division, Birmingham, at the age of 32.

Mr. Geoffrey Bastion Harris, M.A., a Bursar of the British Iron and Steel Research Association, working at the Inorganic Chemistry Laboratory, Oxford, as the result of an accident on 7 March.

Mr. Douglas Jepson, Head of the Department of Metallurgy at the Birmingham College of Technology since 1947, on 24 February, aged 51.

OBITUARY

Mr. W. A. Fowler

William Arthur Fowler, who died suddenly on 16 February 1953, at the age of 60, had spent the whole of his professional career in the light alloy industry in various capacities with The British Aluminium Co., Ltd.

After serving throughout the 1914–18 war, Mr. Fowler received his metallurgical education at Sheffield University, of which he was an Associate in Metallurgy. He was first employed by The British Aluminium Company in their Metallurgical Laboratories at Milton in 1922. He became a Superintendent at the Warrington factory in 1925 and Assistant Manager in 1930. In 1934 he returned to Milton to take over the management of that Works. From 1943 to 1945 he managed not only the Milton, but also the Warrington factory. In 1946 he was transferred to Scotland to manage the Company's rolling mill at Falkirk. He held this position until January 1949, when he moved to the Head Office of the Company to become Production Manager for Manufactured Materials. In this capacity he was concerned with the production side of the Company's manufacturing interests, not only at their rolling mills and extrusion factory at Milton, Warrington, and Falkirk, and smelting works at Latchford, but elsewhere in certain subsidiary and associated companies. He held this position until his death.

Mr. Fowler was extremely well liked and respected by all who worked or had associations with him, both in his own Company and outside it. He possessed a most active and original mind, and was keenly interested in every aspect of production metallurgy and management.

Mr. Fowler was joint author, with the writer, of a paper dealing with problems affecting production economy in the rolling of aluminium, which was read before the Institute at its Autumn Meeting in Paris in 1949, and for which the authors were subsequently awarded the W. H. A. Robertson medal.

Mr. Fowler was a Fellow of the Institution of Metallurgists and had been a Member of the Institute of Metals since 1920.

W. J. Thomas.

LETTER TO THE EDITOR

Dislocation Theories

In your abstract of Mme. A. R. Weill's paper " Mechanism of Plastic Deformation. . . . According to Recent Papers of W. A. Wood ",[1] it is remarked that my interpretation of my results makes no appeal to the theory of dislocations and polygonization. May I qualify that?

The main results are: (i) plastic deformation in general reduces the metallic grain to a sub-structure; (ii) the size distribution of the elements depends systematically on the conditions of deformation, e.g. temperature and rate of strain; and (iii) the size distribution largely determines the strain-hardening.

I interpret the first two in terms of dislocations. It has been evident from the beginning that any boundary is a surface of dislocations, vacant sites, and interstitial ions and therefore that the sub-boundaries form by a segregating of such imperfections. Differences have arisen only in picturing the segregation. I have taken the view that it was the natural and virtually immediate consequence of trying to bend or otherwise deform a lattice already studded with imperfections. The alternative view postulates polygonization. This, as first proposed, was a two-stage process: first a considerable bending of the lattice; then a flow of imperfections to the boundaries-to-be, but only after a heat-treatment. My difficulty was with this need for temperature-activation. It seemed contrary not only to our own evidence but also to the beautiful X-ray work with micro-beams at Cambridge and elsewhere, which demonstrates that plastic deformation produces sub-structures at room temperature and even at liquid-air temperature.[2] If it turns out that temperature-activation is unnecessary, there will be little to choose between the two views.

The third result presented more difficulty. The obvious interpretation was that the network of dislocations and other imperfections forming the sub-boundaries also provided a force-field sufficient to impede the flow of other dislocations and so cause the strain-hardening. A hardening effect by sub-boundaries was reasonable on general grounds. It was a logical extension of the well-known observation that a metal is harder, the smaller its grain-size. It also received some theoretical support from Bragg's theory of yield. Moreover, in the later work [3] on " stress-recovery ", we could directly follow and correlate changes in hardness with changes in sub-grain size. But it was difficult to reconcile the observations with the generally accepted dislocation theory of hardening due to G. I. Taylor. This postulated that the necessary field was provided by an array of positive and negative dislocations alternating in space like the sodium and chlorine atoms in a rock-salt structure. It seemed that a purely hypothetical array for which there has never been any direct experimental evidence was taking the place of a natural array for which evidence has continually accumulated.

However, it now appears from the theory of strain-hardening recently put forward by Mott [4] that the Taylor solution is not unique and may be effectively replaced by a sub-boundary array after all. It is too early to say whether the network pictured by Mott is also that observed experimentally, but it would seem that the theoretical and experimental approaches are converging for the first time. I should like to make it clear, therefore, that the interpretations in question are not at variance with the general theory of dislocations, but only with certain forms which that theory has taken and which I suggest are open to legitimate criticism.

W. A. Wood.

The Baillieu Laboratory,
University of Melbourne.

REFERENCES

1. A. R. Weill, *Mem. Artillerie Franç.*, 1952, **26**, (1), 41; see *Met. Abs.*, 1952–53, **20**, 232.
2. P. A. Beck, private communication.
3. W. A. Wood and J. W. Suiter, *J. Inst. Metals*, 1951–52, **80**, 501.
4. N. F. Mott, *Phil. Mag.*, 1952, [vii], **43**, 1151.

ROLLS AND THEIR MAINTENANCE IN THE NON-FERROUS METALS INDUSTRY

B4

An informal discussion on "Rolls and Their Maintenance in the Non-Ferrous Metals Industry", was held at Birmingham University on the 8 January 1953, the Chair being taken by Mr. W. J. Thomas, Chairman of the Metallurgical Engineering Committee.

In accordance with the Chairman's request in his opening remarks, the discussion comprised, firstly, an account by roll users of their experience and their views on desirable developments in rolls; secondly, comments by representatives of roll makers on what had been said by roll users; and, finally, a general exchange of views on various aspects of roll maintenance.

The following is a summary of the discussion under these headings.

Roll Usage: Experiences &c., of Roll Users

Rolling of Light Alloys

(a) *Hot Rolling*

With rolling speeds of about 450 ft./min. and metal temperatures ranging from 250° to 530° C., two-high hot mills having roll barrels up to 35 in. in dia. by 96 in. in length, and four-high mills of sizes up to 24 and 56 in. by 88 in., are employed.

Various types of rolls, namely chilled iron, cast steel, composite forged steel, and solid forged steel, have been used in two-high hot mills. Chilled-iron rolls, which have been used quite successfully in small hot mills, cannot be employed in the larger modern mills because the heavier rolling load calls for a journal/barrel diameter ratio of 4:5, and conventional mill designs will not accommodate rolls of these proportions. Composite forged-steel rolls have been used with some success in the smaller mills, but have proved unsuitable for the larger mills. Repeated failures of composite roll shells, either by total fracture or by their lateral displacement on the arbors or even fracture of the arbors themselves, have resulted in the rejection of this type of roll for hot-rolling duty. In the case of a mill having composite rolls 34 in. in dia. by 72 in. in length, it has been found that the average mill throughput before scrapping was 12,000 tons per roll, each roll having been reshelled once during its life.

The present trend for hot-rolling duty is to use solid-forged rolls of 65°–70° hardness, as measured on the Shore Type C Scleroscope, the hardness being critical, since experience has shown that rolls of 78°–80° hardness are subject to severe spalling, necessitating, on occasion, barrel reductions of $\frac{1}{2}$–$\frac{3}{4}$ in. for its removal. An analysis of the tonnage rolled with 78°–80° hardness rolls before scrapping reveals a figure of 22,000 tons per roll. Rolls of 50°–55° hardness, although not subject to spalling, suffer from persistent superficial cracking. Solid-forged rolls of 65°–70° now in use have proved to be fully resistant to indentation, and although the tonnage rolled already exceeds 41,000, no cracking, crazing, or spalling has been experienced. In general, the reason for changing these rolls has been the development of pitting of the barrel surface that usually appears at service tonnages of between 5000 and 8000. The cause of this pitting is under investigation.

One of the principal problems requiring the attention of roll makers and rolling-mill manufacturers is the question of roll journal wear. It has been observed that whereas formerly the ultimate potential roll life was determined by the rate of barrel wastage through grinding, the extent and frequency of such grinding have been so reduced that journal wear now threatens to dictate ultimate potential roll life. Attention to the degree of hardness and possibly also local hardening to resist wear is therefore necessary. In addition, attention should be paid by mill makers to the possibility of equipping two-high hot mills with totally enclosed bearings, which have the virtue that a separate cooling cum lubricating solution can be used for the journal bearings.

In four-high hot mills solid-forged steel work-rolls are used in conjunction with cast- or forged-steel back-up rolls. The principal trouble experienced is the total failure of both cast and solid-forged steel back-up rolls. These failures have generally taken the form of total fracture along a plane roughly at right angles to the axis of the roll, and a development in manufacturing technique is required to eliminate the causes of failure of these costly rolls, which is usually attributed to internal stresses.

(b) *Cold Rolling*

For strip rolling, solid-forged steel work-rolls are almost universally used in both two-high and four-high mills, and considerable experience has been gained with both American and British rolls for this duty. Until a few years ago difficulty was experienced in this country in obtaining, in the sizes needed, rolls which were sufficiently hard to prevent rapid deterioration of the barrel surface, but which, at the same time, were resistant to indentation and spalling. American rolls possessed these desirable features, particularly the former. The American rolls were described as "deep hardened", having a usable hardened case $\frac{3}{8}$ in. thick, and experience has shown that for a diameter reduction of $\frac{1}{4}$ in. on these rolls, no deterioration in the surface hardness occurs. Up to one or two years ago British rolls of the same size developed spalling and severe indentations, and after a barrel diameter reduction of $\frac{1}{4}$ in. the surface hardness dropped by 10°–18°. As the indentations might occur at any time while the rolls were in service in the mill, they involved the roll user in the problem of roll changing on a day-to-day or even hour-to-hour basis. Similarly, rolls of inadequate surface hardness involved the user in too-frequent roll changing owing to the rapid deterioration of the barrel surface.

Records show that American rolls were, up to one or two years ago, giving about two and a half times the length of service between regrinds as were given by those of British manufacture, but rolls recently made in this country are showing considerable promise in extended periods of service between regrinds and resistance to indentation without an undue increase in the incidence of spalling.

This recent experience indicates that the development of

manufacturing technique in producing work-rolls for the cold strip rolling of light alloys should continue to be in the direction of increasing the depth of hardened case, with attention being paid also to the intrinsic hardness of the barrels.

Back-up rolls for four-high cold strip mills may be of forged steel, either solid or of composite construction, or cast steel. Composite forged-steel rolls have given very variable performances, whereas both solid-forged and cast-steel rolls have given consistently good results. In general, solid-forged and cast-steel rolls are now favoured for this duty. It has been noted that cast-steel rolls wear roughly twice as quickly as forged-steel rolls when engaged on identical rolling duties. Actual figures taken over a period of 9 years show that the tonnage rolled per inch of reduction of the barrel diameter in the case of cast-steel back-up rolls was 350,000, and that for forged-steel rolls 650,000. The hardness of the cast rolls was 50°–55° and that of the forged rolls 70°–75°.

Cast-steel rolls, which are at present limited in hardness to about 55°, require to be developed to give the higher hardness necessary to resist wear. Forged rolls, when supplied in the hardness range 70°–75°, have the virtue that they mark or suffer indentation rather than the work-rolls when pieces of the rolled stock pass accidentally into the " bite " of the work and back-up rolls. Higher hardness back-up rolls are used, however, and one roll maker subsequently pointed out that in the U.S.A. the tendency is to increase the hardness of back-up rolls in order to increase their resistance to deformation during rolling.

In the case of the flat-sheet rolling of light alloys, the problems in terms of surface finish are similar to those in strip rolling. The types of roll employed are solid-forged steel and both the clear and indefinite chilled irons. Past difficulties in controlling the defects of mottled surfaces and colour variation are now being overcome in the indefinite chill roll of 90°–95° Shore hardness. In general, the forged-steel roll gives a 40% better mill life than the chilled-iron roll, but the choice of the type of roll to be used is a domestic issue, depending on the type of mill in use and the product being rolled.

Rolling of Copper, Brass, Zinc, Cupro-Nickel, &c.

Hot rolling is carried out at temperatures ranging from 250° to 950° C. In general, indefinite chill rolls are employed, but some forged-steel rolls are used, particularly where a variety of alloys is being processed. The initial cost of forged-steel rolls is much higher than that of chilled-iron rolls, but, under comparable operating conditions, the roll life is proportionately longer. It was suggested that a composite roll comprising a steel arbor with a cast-iron shell might be the most suitable.

In cold breaking-down mills of the four-high type, forged-steel work-rolls of 80°–90° hardness are used. Although rolls of this hardness tend to mark easily, any increase in hardness gives rise to spalling owing to the heavily loaded condition of these mills. The tonnage rolled with present-day forged-steel rolls shows considerable improvement over that obtained about 16 years ago. The average output per roll obtained in a 15-in. and 36 × 32-in. four-high mill in 1936 was 14,000 tons, whereas in this same mill recent output figures average 51,400 tons per roll.

Cold-finishing mills employing chilled-iron rolls generally demand a hardness of 95° minimum, but even at this hardness marking is prevalent, and maintenance of the required surface finish, particularly on sheets, is difficult. A number of forged-steel rolls stated to be 28 in. in dia. by 16 in. long, obtained before the War from the Continent and during the War from America, gave very good service, but there is reluctance on the part of some British manufacturers to supply forged-steel rolls of such a size for this duty.

Rolling of Nickel Alloys

Some of the most severe working conditions encountered by rolls in the non-ferrous metals industry arise in both the hot and cold rolling of nickel alloyed with such metals as cobalt, iron, chromium, molybdenum, and copper.

Hot-rolling mills operate at temperatures up to 1300° C., and difficulty is experienced in obtaining rolls that will withstand the heavy rolling pressures at these high temperatures. In the case of a three-high mill with 16-in.-dia. rolls, handling billets 7 in. wide × 2 in. thick, chilled-iron rolls failed owing to fracture, severe crazing, or rapid wear of the barrels. The more expensive solid-forged steel rolls of 63°–65° hardness give reasonable service and are now used for hot-rolling duty, but trials are being carried out with so-called " steel-base " rolls, the results of which are not yet available.

Cold breaking-down of nickel alloy strip from about 0·30 in. gauge to about 0·048 in. is carried out on either two-high or four-high mills. In a two-high mill, employing rolls 14 in. in dia., cast-steel rolls have entirely superseded chilled iron for this arduous duty. A four-high mill engaged on similar work is equipped with 7 in.-dia. forged-steel work-rolls of 100° hardness and 12-in.-dia. steel back-up rolls. The hardness of the back-up rolls has been limited to 75°, as it has been found that rolls of greater hardness tend to skid on the work-rolls.

In the cold-finish rolling of nickel alloys, perfection of surface finish is not the prime consideration, but accuracy of gauge is important. A high degree of work-hardening is desirable when cold rolling to thicknesses less than 0·001 in., and this subjects the rolls to intensive loading. Rolls of extreme hardness, capable of withstanding high pressures, are essential for cold-finishing duty in order to prevent grooving of the barrels by the passage of the strip.

Mills of various types are used for cold-finishing work including four-high mills with 5-in.-dia. work-rolls for reductions in strip thickness down to about 0·005 in., four-high mills with 2-in.-dia. work-rolls for reductions down to 0·0015 in., and twelve-roll mills with $\frac{3}{8}$-in.-dia. work-rolls for rolling to the finest gauges. The hardness of forged-steel rolls on this duty is limited to 105°, since higher values are accompanied by spalling and cracking.

The application of solid carbide work-rolls of $\frac{3}{8}$ in. dia. has proved successful on the twelve-roll mill, with the advantage of greater reductions. Both solid carbide and composite carbide-shell rolls having a steel arbor are under consideration for 2-in.-dia. work-rolls.

Roll Manufacture and Usage : Comments by Roll Makers

Spalling of rolls is common to most branches of the non-ferrous metals industry, particularly where the duty calls for a high degree of roll surface hardness. It was suggested that the origin of a spall lay in small flaws or inclusions giving rise to fatigue cracks which develop under the very considerable stresses set up during rolling, but, on the other hand, it was stated that such flaws might not be inherent in the roll but might be caused by severe local overloading. (On this

point, subsequently, a roll-user suggested that breakdown of lubrication might also give rise to spalling.)

Spall resistance in chilled-iron rolls is greater in the indefinite chill type than in the clear chill rolls because the microscopic graphite seeds present in the outer hardened case of the roll give a cushioning effect by taking up some of the local overloads that occur during rolling. The hardness limit for indefinite chill rolls is 95°.

The structure of a chilled-iron roll comprises a white-iron outer case, which is carbidic in essence and, hence, brittle, but has a very high compressive strength. Immediately behind the carbidic zone is the transition zone of mottle iron followed by the core, which is of grey iron. Hard alloy chilled-iron rolls are simple alloys containing nickel, chromium and molybdenum or nickel and molybdenum or manganese and nickel.

Where chilled iron or steel rolls exhibited "craze-cracking", it was contended that the remedy lay with the roll users, who should either modify their rolling technique, or alternatively remove the cracking in its early stage by frequent grinding.

Fully hardened alloy forged-steel rolls are manufactured in this country with barrels up to 32 in. in dia. and 96 in. in length, the hardened portion of a 95°–100° Shore hardness roll having a tensile strength of the order of 200 tons/in.^{2} and a compressive strength probably in the range 300–350 tons/in.^{2}.

Premature failure of forged-steel rolls may be associated with the quick stress and temperature reversals that take place in reversing mills, since there is some evidence that premature failures are attributable to a process of fatigue of the roll metal taking place progressively from the outside towards the inside of the roll section.

The problems of initial roll surface hardness and its penetration to a predetermined depth in the body of the roll are receiving active attention from roll makers in this country. Rolls with a surface hardness up to 105° Shore, and also rolls of lower surface hardness but having deeper penetration, are obtainable from manufacturers in this country.

A plea for standardization of drive-end design was registered by roll makers, with a departure from the lobular type of roll wobbler, which calls for extensive machining on forged-steel rolls.

Roll Servicing, Maintenance &c.: General Discussion

Hardness Measurement

The instrument employed for the hardness measurement of finish ground rolls is the Shore Scleroscope, the principal merits of which are portability and measurement without destruction of the surface. It provides neither an absolute measure of hardness nor a measure of resistance to indentation, but rather a comparison of material resilience. Furthermore, facilities appear to be lacking for the proper recalibration of these instruments against recognized standards, wide discrepancies having been noted between different instruments.

Roll makers employ the diamond hardness test during the manufacture of a roll and, by making standard sample blocks of various hardness values, are able to check their Scleroscopes against the diamond hardness figures; roll users, however, naturally avoid the use of the diamond test or any other test instrument which is destructive of the surface being measured.

It was concluded that the Scleroscope is a satisfactory comparator subject to the institution of periodic calibration against recognized standards.

In the absence of information about the physical characteristics and specification of the rolls supplied to him, the roll user is generally obliged, when comparing roll performances, to identify the rolls by their Scleroscope hardness. Roll makers should, therefore, give more information about the mechanical properties and metallurgical composition of their rolls so that users can determine from experience the most suitable roll specification for a particular duty.

Roll Journals and Oil Seals, &c.

Adequate oil sealing in high-speed rolling mills engaged on light alloys constitutes a major problem, with particular reference to the preferential roll journal wear over those areas in contact with the oil seals. Failure of an oil seal often occasions a roll change because of the loss of bearing oil into the rolling oil system, with its attendant effect on roll-bite conditions, staining of the product, and the resulting rejection of the rolling lubricant for contamination. A possible solution lies in the provision by roll makers of locally hardened journal areas to resist seal wear. Wear of the journals might be adjusted by some form of rebuilding, such as metal spraying, since their reconditioning by this means has met with some success where journal loadings are not high.

Roll Grinding

Grinding of sheet and strip mill work-rolls is necessary when the surface condition has deteriorated to such an extent that the surface finish of the product is no longer acceptable or that the life of the roll is endangered. Deterioration may take the form of indentation, cracking, spalling, grooving, or other roll-surface markings which affect the rolled product. Back-up rolls, on the other hand, are often left in service, particularly in light-alloy mills, for a definite planned period, frequently as long as six months, without any apparent detriment to the roll. In order to ensure that any fatigued or work-hardened metal is removed from cast-steel back-up rolls after such a period of service, it was urged by a roll maker that the roll diameter should be reduced by about 0·040 in.

The attainment of the roll surface finishes and cambers currently required calls for precision grinding on accurate machines, using grinding wheels of good and consistent quality. The point was made that in the case of British machines there was scope for improvement in respect of more robust construction and precision of design, so that a uniform high roll finish could be consistently achieved with the machine without making a heavy demand on the skill of the operator.

Heavy grinding work should be confined to machines allocated for that purpose, leaving accurate finish grinding to machines allotted to precision duty. Close attention should be paid to the concentration and temperature of the grinding-wheel coolant, and above all it is imperative that grinding wheels be accurately balanced.

Appreciable variation is experienced by some users in the quality of grinding wheels to the same specification, particularly with fine wheels such as 500 grit. The surface finish obtained with a particular wheel is often difficult to reproduce with a second wheel to the same specification.

It was suggested by one roll user that it would be advantageous if grinding machines were so designed as to equip them with means for selecting a choice of camber shapes, since, at present, the only shape obtainable is that resulting from the particular camber mechanism incorporated by the

makers in their machine. (This remark may occasion some surprise, and it is thought that the speaker intended to convey that British machines are not equipped with a device for adjusting camber shape, although, of course, changes can be achieved by fitting modified camber generating mechanisms.)

As an illustration of high-precision grinding of rolls for use with nickel alloys, grinding tolerances of less than 0·00002 in. are demanded for rolls engaged on strip gauges down to 0·0002 in. These requirements were said to be met by a machine of Swiss manufacture, but no indication was given of the measuring means appropriate to such fine tolerances.

Protection of Roll Surface

After grinding the rolls, it is essential that the ground surfaces be quickly protected from atmospheric corrosion. Various materials are used for this purpose, including corrosion-resistant greases, non-setting paints, and hard varnishes. Vapour inhibitors are also used with some success, but the choice of protective material is a domestic issue, experience dictating the most suitable medium. After application of the protective material, the rolls should be stored in a warm, dry atmosphere clear of the shop floor and supported on timber bearers.

NEWS OF LOCAL SECTIONS AND ASSOCIATED SOCIETIES

Sheffield Local Section

At a joint meeting of the Sheffield Local Section with the Sheffield Society of Engineers and Metallurgists and the Sheffield Metallurgical Association, held at the University on 16 February, Mr. W. A. Baker, Research Manager to the British Non-Ferrous Metals Research Association, gave a lecture on:

The Constitution and Properties of Some Titanium-Base Alloys

After a brief reference to the composition and other characteristics of iodide titanium and of the sponge (Kroll) material, the lecturer referred to the effects of various alloying elements on the stability of the α and β phases, illustrating his remarks by reference to three typical phase diagrams. The mechanical properties of the metal and of a number of its alloys were then discussed and were related to certain features of the constitutional diagrams. The lecture concluded with a few general comments on the engineering properties of titanium and its alloys and on the behaviour of the materials in fabrication.

OTHER NEWS

Heat-Treatment Practice

Preliminary notice is given by the British Iron and Steel Research Association of a conference on Heat-Treatment Practice to be held on June 15, 16, and 17 next, at Ashorne Hill, Leamington Spa. It is intended that there shall be papers and discussion on the heat-treatment of engineering steels and large forgings and sections, surface treatments, isothermal heat-treatment, and temperature measurement and control.

The conference, which is being organized by the Metallurgy (General) Division of B.I.S.R.A., is expected to provide a meeting ground for engineers and steelmakers affected by these problems. Any persons wishing to attend should apply to Mr. A. M. Sage, B.I.S.R.A., 11 Park Lane, London, W.1.

DIARY

7 May. Leeds Metallurgical Society. Annual General Meeting, followed by Junior Members' Papers. (Chemistry Department, The University, Leeds 2, at 7.15 p.m.)

13 May. Society of Chemical Industry, Corrosion Group. Annual General Meeting, and Chairman's Address by Dr. W. H. J. Vernon. (Chemical Society, Burlington House, Piccadilly, London, W.1, at 6.30 p.m.)

14 May. Institute of Metal Finishing, North-West Branch. "The Metal Finishing of Non-Metallic Materials", by H. Ashton. (Engineers' Club, Albert Square, Manchester, at 7.30 p.m.)

18 May. Institute of Metal Finishing, London Branch. "Instruments for the Determination of Coating Thickness: A Review of Commercial Instruments", by E. S. Spencer-Timms. (Northampton Polytechnic, St. John Street, London, E.C.1, at 6.0 p.m.)

APPOINTMENTS VACANT

GALVANIZING (HOT-DIP). Manager required for old-established galvanizing works in Midlands. General work, malleable castings, tubes, sheet metal work, grey iron castings, wire work, &c. Present output running between 50 and 100 tons per week. The manager would be required to plan production, organize all labour, and supervise the care of all equipment. Man with previous experience preferred; alternatively man with technical qualifications would be considered. Salary, according to qualifications, would be made up of basic monthly salary plus a bonus on profits of the department. Applications will be treated in strictest confidence. Please write in first instance to A. A. Black, Limited, (Dept. Y), 113 Bristol Road, Birmingham, 5.

METALLOGRAPHER for laboratory near Northampton engaged in development of components and materials for the radio, electronic, and radar industries. Work would include investigations of a variety of special metallic and ceramic materials. Few years' experience essential. Salary according to age, qualifications, and experience. Box No. 350, The Institute of Metals, 4 Grosvenor Gardens, London, S.W.1.

METALLURGIST, with University qualifications, required for investigational work on problems associated with the welding of steels. Some experience in research or industry essential and a knowledge of arc welding an advantage. Excellent salary and prospects for suitable applicant. Apply in writing to Box JIM 205, LPE, 110 St. Martin's Lane, London, W.C.2.

MINISTRY OF SUPPLY, Royal Aircraft Establishment, Farnborough, Hants, requires metallurgist to work in team engaged on titanium alloy development. Qualifications 1st or 2nd class honours degree or recognized equivalent in metallurgy. Preference for and skill in experimental work, especially metallography, required, experience of metallurgical research desirable. Salary within range, Scientific Officer, £417–£675. Women somewhat less. Post unestablished. F.S.S.U. benefits may be available. Application forms from M.L. & N.S. Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F108/53A. Closing date 15 May, 1953.

THE MOND NICKEL COMPANY, LIMITED, requires a manager for its research department situated at the refinery in South Wales. The position is of high seniority and importance, and a commensurate salary will be paid. A house is available for residence, and the Company operates a retirement pension scheme. Applicants should preferably be not more than 40 years of age, have had good research experience, and be competent to inspire and lead a team investigating physico-chemical problems. Applications, which will be treated as confidential, should be addressed to The Resident Director, The Mond Nickel Company, Limited, Clydach, Swansea.

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THERMODYNAMICS OF ALLOYS

By JOHN LUMSDEN, B.Sc.

(Research Department, Imperial Smelting Corporation, Ltd.)

Institute of Metals Monograph and Report Series, No. 11 *Cloth,* 390 *pp. with* 110 *illustrations*

Price 35s. or $5.50 post free. (Members, one copy at 17s. 6d. or $3.00 post free.)

This monograph deals with the application of thermodynamics to the quantitative study of metals and alloys. The fundamental theory of the subject is presented first, and is followed by some illustrative calculations on pure metals. Then the theory of solutions is developed and exemplified by calculations on solid and liquid alloys. Emphasis is laid on the usefulness of thermodynamics for the accurate correlation of various equilibrium properties. Attention is particularly directed to the information that can be deduced from phase boundaries. Detailed calculations are presented on some typical systems for which measurements of vapour pressures, electrode potentials and heats of mixing are available; these results are combined with a study of liquidus, solidus and solid-solubility curves to derive the activities of both components in the liquid and solid phases. It is shown how a free-energy equation for a system, deduced from a suitable set of accurate experimental measurements, furnishes a reliable basis for calculating other equilibrium properties. To assist in numerical calculations, tables of functions that continually recur in thermodynamic problems are provided.

Elementary statistical mechanics is introduced for calculating the entropy of gases and for interpreting the form of free-energy curves in solid and liquid alloys. A critical study is made of the extent to which liquid alloys behave as " regular solutions."

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INSTITUTE DINNER AT THE PARK LANE HOTEL, LONDON, 24 MARCH, 1953. [*Photo: Lawson and Co.*

The President (Professor F. C. Thompson) was in the Chair, and the Principal Guests were Air Commodore F. R. BANKS, C.B., O.B.E. (Principal Director of Engine Research and Development, Ministry of Supply) and the Deputy Mayor of the City of Westminster.